étendre les parties extrèmes du spectre au delà des limites observées par Fraunhofer. Les nouvelles parties du spectre, avec leur raies sont représentées dans la Fig. 4, qui est la reproduction du dessin communiqué par Mr. Mathiessen.

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*PROFESSOR FONTAINE AND DR. NEWBERRY ON THE AGE OF THE POTOMAC FORMATION.*

THE appearance at this time of two important works on the Potomac formation, though both of them have been long delayed in publication, is peculiarly opportune in view of the discussion now going on in relation to the age of that formation. These works are first, that by Professor Fontaine on the Potomac Formation in Virginia,* and second, that of Dr. J. S. Newberry, on The Flora of the Amboy Clays.†

The greater part of the matter of the first of these works was originally submitted by Professor Fontaine as an introduction to his important work on The Flora of the Potomac Formation,‡ giving a somewhat detailed account of the stratigraphical relations of the Potomac formation in Virginia. But it was thought best to omit this introductory part and publish it separately. Owing to causes which need not be here enumerated, the publication of this part of his work was long neglected, but is now hapily before the scientific world.

As its name implies, this treatise is confined mainly to those portions of the Potomac formation which lie south of the Potomac River, *i. e.*, almost exclusively to the State of Virginia, and only contains incidental references to the condition of things in Maryland. A consequence of this is that it deals wholly with the Older Potomac and does not attempt to discuss the prolongation of the formation through New Jersey and northeastward, where all the beds thus far found belong to the Newer Potomac, which finds its greatest exemplification in the Raritan and Amboy Clays.

The second of these works, on the contrary, deals exclusively with the Newer Potomac, but under the term Amboy Clays Dr. Newberry expressly included all that was known to him of those beds which occupy the north shore of Long Island and are found all the way from Staten Island to Marthas Vineyard. Although I have designated these latter beds as the Island Series, and have sufficiently demonstrated the justness of this subdivision, I have at the same time admitted that the character of the flora is substantially the same throughout.

We thus have two new contributions to the subject under discussion written by able men who are not exclusively nor chiefly paleobotanists, but are known to the world as geologists of the first grade, each of whom prior to writing his work had devoted many years to an exhaustive study of the formation to be dealt with. Although much has been learned since the date at which these works were written, it is not proposed in this paper to make special reference to such discoveries, as they have been for the most part fully set forth in a series of papers by Mr. David White, Dr. Arthur Hollick and myself, an acquaintance with which will be assumed on the part of the reader.* But

* The Potomac Formation in Virginia, by William Morris Fontaine, Bull. U. S. Geol. Surv., No. 145, Washington, 1896.

† The flora of the Amboy Clays, by John Strong Newberry. A posthumous work, edited by Arthur Hollick. Monographs of the U. S. Geological Survey, Vol. XXVI., Washington, 1896 (erroneously dated 1895).

‡ The Potomac or Younger Mesozoic Flora, 2 Vols. text and plates. Monographs of the U. S. Geological Survey, Vol. XV., Washington, 1889.

* See Bull. Geol. Soc. Am., Vol. I., p. 554; Vol. VII., p. 12; Am. Journ. Sci., 3d Ser., Vol. XXXIX., p. 93; Trans. N. Y. Acad. Sci., Vol. XI., p. 96; Vol. XII., p. 1, 222; Vol. XIII., p. 122; Bull. Torr. Bot. Club, Vol. XXI., p. 49; Fifteenth Ann. Rept. U. S. Geol. Surv., p. 307; Sixteenth Ann. Rept. U. S. Geol. Surv., p. 463.

the treatises here mentioned give the matured views of their authors, and in the case of Dr. Newberry this work constitutes almost his last contribution to science. I would therefore ask the privilege of directing the attention of those geologists who are interested in the discussion of the age of the Potomac formation to the opinions of these two authors, and I have no apology to make for quoting somewhat freely from them. I will also take the liberty of italicizing, on my own responsibility, those passages which I regard as bearing most directly upon the subject.

When Professor Fontaine commenced his studies he was confronted by the views of Professor Rogers, who, although he had recognized the clear distinction between the Triassic formation and the higher Mesozoic beds and had designated the former as 'Jura-Trias' and the latter as 'Jurasso-Cretaceous,' inclined to regard the whole as belonging below the Cretaceous. It therefore required paleontological evidence to settle the question. Some fossil plants had been found in the Trias which were determined by Bunbury, but, on account of the imperfect material and of the little that was then known of the Mesozoic floras, he was disposed to regard them as indicating an age similar to that of the Oolite of Yorkshire. This view had been completely disproved by Professor Fontaine's previous studies of 'The Older Mesozoic,' as embodied in his work on that flora,* and he had correlated it with those transition beds in Europe and other countries which lie on the border of the Triassic and Jurassic and are known as Rhetic. Since that work was published Stur discovered at Lunz, in Austria, a flora which corresponds still more closely with that of America, even containing a number of the same species, the beds yielding it having been definitely fixed in the Upper Keuper, and we may now look upon this as the more correct correlation.* After giving an account of the manner in which the fossil plants of the Younger Mesozoic were discovered and of their general character Professor Fontaine says (p. 14): "None of these fossils have been found in the Richmond coal field, and, so far as known, *none of the supposed older Mesozoic areas contain any of them.* It is sufficient to say here that this flora indicates that the Potomac beds were laid down in a period *decidedly more recent* than that in which the middle secondary strata of Rogers were deposited." Again, on p. 142, referring to the same subject, he says:

"In Virginia the youngest formation upon which the lower, or sandy member of the Potomac is seen to rest, is the older Mesozoic or Rhetic formation. The interval of time, however, between the deposition of the Rhetic and the deposition of the Potomac beds must have been a considerable one. There are several reasons for coming to this conclusion: (1) Where the superposition of the Potomac on the Rhetic is visible the latter is seen to have been greatly worn before the deposition of the former. (2) The lithologic and structural character of the two formations is very different, implying a total change in the conditions of deposition. (3) The Rhetic is made up of sandstones and shales which are distinctly bedded, so that the dip and strike can be easily made out. The materials composing these beds were well sorted by water action. Before the deposition of the Potomac the Rhetic strata had been consolidated and, in the main, indurated, so as to form firm sandstones and shales, or even slates. The Rhetic beds are in many places crushed, contorted, and faulted, all of which changes took place before the Potomac age. No traces of them

* The Older Mesozoic Flora of Virginia. Monographs of the U. S. Geological Survey, Vol. VI., Washington, 1883.

* Cf. Bull. Geol. Soc. Am., Vol. III., p. 31.

are found in the Potomac. The Rhetic is also penetrated by numerous dikes of igneous rock, none of which pass into the Potomac beds. The interval of time separating the two formations must, then, have been long enough to permit the occurrence of important geologic changes. These resulted in the draining off of the Rhetic waters and in the lateral compression of the Rhetic areas, which caused crumpling and faulting of the strata and outpours of igneous rock. The Rhetic basins were elevated and formed into dry land, subjected to great erosion, and the most eastern of them then depressed and brought under water again. *Certainly no Rhetic species of plant survives into the Potomac.*"

From all this it is apparent that the Older Mesozoic or Triassic formation of the Atlantic border has really nothing to do with the Potomac formation. Only in a few places, as through parts of New Jersey and in Virginia for a short distance in the vicinity of the North Anna and South Anna Rivers, are the two formations in contact, and here the latter rests in complete unconformity upon the former. At all other points they are separated by an interval of greater or less width of the old crystalline rocks. This shows that the Trias, as well below the Hudson as in the Connecticut Valley, constitutes a trough and forms no part of the Coastal Plain proper, having its affinity much more closely with the Piedmont Plateau. The fact that not a single Triassic species passes up into the base of the Potomac further proves that that interval must have been an exceedingly long one, and it is quite in conformity with the facts to suppose that it embraced the entire Jurassic period.

The little that Professor Fontaine has to say of the relations of the Virginia beds to those of Maryland and farther north is important and shows that, although he had not studied the latter except in a general way in Maryland, he had nevertheless formed a tolerably accurate opinion as to their nature. On page 14 he says:

"It should be stated that there is reason to think that the extensive formation of clay and fine sand known in Maryland as the 'variegated clay formation,' or the 'iron-ore clays,' may belong to the same general epoch as the Potomac of Virginia, forming an upper member of the group of which the Virginia Potomac is the lower. The Virginia beds and those of Maryland cannot now be certainly separated by any sharp differences; hence, for the present, the Virginia strata must be regarded as Lower Potomac, and the Maryland formation as Upper Potomac." And, again, on page 142 he makes the following statement:

"On entering the District of Columbia two members of the Potomac formation may be recognized. The lower is that traced through Virginia, and this is the only member recognized in that State. From the predominance of sand and sandstone in this it may be called the sandy member. The other, or upper member is composed of sands and clays, mostly the latter, both being usually highly colored with tints due to oxide of iron. The clays greatly predominate. They have the colors arranged in irregular spots, patches, and seams, and on account of this they have been called by Mr. Philip Tyson and Professor Rogers the variegated clay group. This is the upper member of the Potomac described at Fort Washington.

"*The sandy lower member of the Potomac is visible at Washington and at several points between Washington and Baltimore, in the vicinity of the Baltimore and Ohio Railroad.* The farthest point north at which it has as yet been seen is Baltimore."

It is clear from this that Professor Fontaine believed that the Older Potomac existed in Maryland. I remember his saying to me at about the time that I began my

studies of the formation in that State that he thought the cycads came from the sandstone member, and he once took me to see what he regarded as a typical exposure, on the Patapsco, near Relay, of the basal arkose, identical with certain phases that it presents in Virginia. This observation has been abundantly verified.

In common, however, with the prevailing opinion at that date, which was shared by Mr. McGee and myself, he regarded the iron ore clays, so-called, as somewhat higher and as constituting an 'Upper Clay Member.' At that time no other fossils than cycads, silicified wood and lignite had been found in the iron ore belt. Within the last two years, however, Mr. Arthur Bibbins has demonstrated the occurrence of fossil plants representing a considerable variety, but chiefly consisting of ferns and conifers. He finds them not only in the iron ore deposits, but in the iron ore itself, and I have had the satisfaction, in company with him, of collecting a large number of these and also of examining the much larger collection which he has made. Although these collections have not yet been elaborated and fully determined, a simple glance at them would be sufficient to show that they represent a flora substantially identical with that of the basal Potomac in Virginia, as typified in the Fredericksburg deposits. At the same time that Mr. Hatcher collected the bones in these beds which were described by Professor Marsh, and which constitute the only paleontological evidence that he has thus far brought forward as to their age, he also obtained, in intimate association with the vertebrate remains, a large number of fossil cones, which belong to the genus Sequoia and were undoubtedly borne on the trees which have furnished the silicified wood. All this is simply confirmatory of the antiquity of the iron ores and of their substantial identity in age with the basal Potomac of Virginia.

Professor Fontaine's general conclusions as to the stratigraphical relations of the Potomac formation are of such value in connection with the views of Dr. Newberry, next to be considered, that they should be given somewhat *in extenso*. They are to be found on pages 143–147 of this Bulletin:

"The New Jersey beds, as is shown by their fossil plants, *are certainly considerably younger* than the Virginia member of the Potomac. So far as is yet known, the Amboy clay is not younger than the Cenomanian of Europe.

"So far, then, as can be determined by the stratigraphy, the Virginia Potomac is considerably older than the Cenomanian and *much younger than the Rhetic.* The evidence from the stratigraphy, so far as it goes, agrees well with that of the fossils found in the Potomac.

"*The Wealden formation is most probably not uppermost Jurassic, but the estuary and marsh equivalent of the oldest marine Neocomian.* What will be said therefore concerning the Neocomian will include the Wealden.

"The flora of the Potomac seems to have been an abundant one. It was rich in species of certain groups, but, as compared with modern floras, it was poor in types. A large amount of fossiliferous material was obtained from points located at intervals between James River and Baltimore. The fossils found will give a fair idea of the general character of the flora. This flora has been studied by me, and is described in Monograph XV of the United States Geological Survey. The comparison of these plants with those of known fossil floras shows somewhat complex relations.

"There is present in the Potomac flora *a Jurassic element* which is large in the very considerable number of *genera* that characterize that system. Some few of the *genera* begin as far back as the Rhetic. This element shows indications of decadence. The number of species of each genus is

very small; generally only one or two. Very few individuals of the species are met with, and they are usually local in occurrence. The species are nearly or quite all peculiar to the Potomac.

"There is an important *Wealden element* in the flora. Many *species* of Potomac plants *are identical with species found in the Wealden of Europe, and this is the oldest known fossil flora that gives any considerable number of plants identical with the Potomac species.* Some of these species of the European Wealden are abundant and widely diffused plants in the Potomac. But while the species common to the European Wealden and the Potomac are noteworthy, there is a still larger number of important species found in the Potomac which are so nearly allied to Wealden species that they are with difficulty distinguished from them. These, although regarded as new species peculiar to the Potomac, *are probably forms representing Wealden species*, being modified by differences of environment.

"The Jurassic and the Wealden elements combine to give a Jurassic or Mesozoic facies to the flora, and hence, so far as they go, give it a comparatively ancient character. The Jurassic or Mesozoic type of flora is, as is known, characterized by the overwhelming predominance of four elements, viz: Equiseta, ferns, cycads, and conifers, and by the absence of angiosperms.*

"*The formations which possess the largest number of species identical with those of the Potomac are those of the Middle Neocomian or Urgonian.* The strata of this age which occur in Greenland (in Kome and other localities) and the Wernsdorf beds of the northern Carpathians yield an Urgonian flora, which Heer and Schenk have described. *In the plants coming from these regions we find the largest number of forms identical with Potomac species.* The number of Potomac species nearly allied to Urgonian forms is still larger. These identical and nearly allied species include many of the most characteristic, abundant, and widely diffused species of the Potomac. If we are to determine the age by the largest number of important species identical with those of known fossil floras, then *we would without hesitation set it down as ranging from the Lower through the Middle Neocomian.* A very large and important element of the Potomac flora is peculiar to this series. In this we find without doubt the most abundant, characteristic, and widely diffused species. As these are new, they can not give any direct evidence concerning the age of the formation, but indirectly the existence of such a large proportion of peculiar forms is favorable to the assumption that the age is Neocomian. The flora of this formation is one of the least known, and any large collection of richly fossiliferous material from beds of Neocomian age could not fail to furnish a great number of new species.

"Then again, the relatively great development of the conifers, along with the existence of an important cycadaceous element, *points strongly to the Neocomian as the era of the formation.* The survival of a considerable Jurassic element in the flora also indicates that it can hardly be younger than Neocomian. While much the most important elements of the flora indicate an age not more recent than the Urgonian or Middle Neocomian, there are some species which point to a more recent era of deposition for the formation. There are one or two species which are probably identical with forms found by Heer in the Cenomanian beds of Greenland. These are local and are represented by very few individuals. A few of the species also may be considered as nearly allied to some

* Both Professor Fontaine and Dr. Newberry use the old botanical classification which made the 'Angiosperms' synonymous with the Dicotyledons. It amounts to about the same thing here, however, on account of the almost complete absence of Monocotyledons in these floras.

occurring in the Greenland Cenomanian. These Cenomanian types are probably to be regarded as precursors not yet fully established, just as the Jurassic types must be considered as survivors not yet extinct.

"*The angiosperm plants present in the flora are much more important in giving a more recent facies to the flora.* They show quite a large number of species, but these are almost always local in occurrence, and are represented in most instances by few individuals. In a number of cases only one or two specimens were found. *It has been generally held that any considerable development of angiosperms in a fossil flora is strong, indeed conclusive, evidence that its age is not greater than that of the Cenomanian.* But apart from the evidence given by the older and predominant elements of the flora, there is reason to think that the Potomac flora is older than Cenomanian, even if we take into consideration the angiosperms alone.

"The conclusion above mentioned is based solely upon the fact that *in no flora older than Cenomanian has any considerable angiosperm element been found up to the present time*, but various writers have with justice maintained that it is improbable that the apparently sudden appearance of angiosperms in great force in the Cenomanian represents the true state of the case. It is highly probable that they had numerous precursors and ancestors, which existed in the Neocomian, and perhaps some of them, at least, in the Jurassic. It is probable that some of the forms called Protorhipis are ancient angiosperms. The existence then of numerous angiosperms in a flora which is predominantly Neocomian, but which contains many surviving Jurassic types, is just what we would expect to find. But we have direct evidence of the existence of angiosperms in the Neocomian. Heer has described from the Kome beds of Greenland, which are Urgonian in age, an angiosperm which he called *Populus primæva*. Only a few specimens were found. This single occurrence has remained so long unsupported by other discoveries of angiosperms in the Neocomian that doubts have been expressed concerning the correct localization of these specimens. It was thought possible that they really came from a younger flora. If the Potomac flora is in fact Neocomian, we have in this case a noteworthy illustration of the truth that positive evidence, however scanty, should outweigh any amount of negative evidence.

"The Potomac angiosperms in their general character give evidence of an age greater than Cenomanian. It is true that we find in them genera, and possibly some species, that survive into the Cenomanian and even down to the present time, but taken as a whole they form a peculiar group, *totally unlike the floras of the Dakota and the Amboy beds.* It is in the flora of the Dakota group, and the Amboy clays of New Jersey, especially the latter, that we would expect to find the greatest number of plants identical with Potomac forms. *Both of these floras are Cenomanian probably, and the Amboy flora, so far as yet known, is the one that comes next above the Potomac.* There are one or two species that are probably common to the Potomac and the Dakota beds, or that are nearly allied, but they are long-lived types, that come down to the present time with little modification.

"By the kindness of Dr. J. S. Newberry, who studied and described the New Jersey Amboy flora, I have been enabled to examine a large number of drawings of the New Jersey plants. *These plants are totally different from those of the Potomac. It is not certain that a single species survives from the Potomac into the Amboy beds. What is even more significant, even the genera that are most abundant in the Potomac and most characteristic of that formation have no representative in the New Jersey flora. It is clear that a very important gap exists between these two floras, and that an interval of time separates them, in which*

*changes took place that produced an extensive destruction of vegetal types and altered the entire character of the flora.*

"The localization of the species of Potomac angiosperms and their slight development, as shown in the very few individuals that in most cases represent them, indicate that these forms are, comparatively speaking, newcomers and precursors or ancestors of forms destined to become the predominant ones. This indication is confirmed by the character of a number of the species. They appear to be complex or comprehensive types, uniting in one form features that in the process of differentiation will later distinguish separate species.

"We may then conclude that the Potomac flora is not exactly like any known, *but on the whole coincides most nearly with that of the Lower and Middle Neocomian.* If this be true, then, we find that in this flora the development of angiosperms in considerable numbers has been pushed back through a long period of time."

In view of the fact that Professor Marsh, Mr. Gilbert and, to some extent, also Mr. Hill, in discussing the age of the Potomac formation, have referred to it as representing one definite epoch in the geological history of the Atlantic border, it does not seem superfluous to emphasize to any extent the fact which I have so prominently brought forward in my paper on The Potomac Formation,* and to which I also called attention in my own contribution to this discussion,† that the Potomac formation, as I have defined it and as also defined by Professor Marsh, including, as it does, the Older Potomac beds of Virginia, the iron ore belt, the purple clays, the white sands and white rocks (Albirupean of Uhler, Magothy of Darton), the Raritan and Amboy Clays of New Jersey, and the red micaceous clay shales of Staten Island, Long Island and Block Island, as well as the variegated clays of Gay Head on Marthas Vineyard, represents a prolonged period in the geological history of the Coastal Plain equal to the entire Lower Cretaceous of Europe, *i. e.*, from the Wealden to the Gault of England, or from the lowest Neocomian to the highest Albian (Vraconnian)* deposits of the Continent.

With this fact in mind we are prepared to consider the still more startling statements contained in Dr. Newberry's Flora of the Amboy Clays. And first it will be necessary to determine precisely what Dr. Newberry meant by the Amboy Clays. This is made sufficiently clear by the following description (pp. 21–22):

"The Amboy Clays, to which our attention is now more particularly directed, outcrop in a belt extending diagonally across the State, forming the east bank of the Delaware River for a long distance above and below Philadelphia, leaving the Delaware at Trenton and stretching across the State at its narrowest point to Raritan Bay, and thence, passing over the southern portion of Staten Island, where, as in the State of New Jersey, they are largely worked for economic purposes. They are then interrupted by the Narrows and New York harbor, as well as by the crystalline rocks which occupy New York Island and underlie the northern portion of Brooklyn and the adjacent shores of Hell Gate. Eastward of this the Amboy Clays are generally covered with drift, but they appear at Glen Cove, Sea Cliff, and various other points on the north shore of Long Island, where it has been deeply cut into by glacial action and is now occupied by inlets from Long Island Sound. Possibly the whole length of Long Island is underlain by the Amboy Clays, as characteristic fossils

* Fifteenth Ann. Rept. U. S. Geological Survey, pp. 307–397, Washington, 1895.

† SCIENCE, N. S., Vol. IV., No. 99, Nov. 20, 1896, p. 757.

* See 16th Ann. Rept. U. S. Geol. Surv., p. 533.

have been found in the moraine on the extreme end of Montauk Point. Farther east, the clay series reappears on Marthas Vineyard and forms part of the noted cliff of Gay Head."

It is therefore clear that he includes in his Amboy Clays all the deposits north of the Delaware River, and that so far as these deposits are concerned they are the same as those to which Professor Marsh has referred in this section of the belt. As regards points farther south he has also made himself tolerably clear by the following language (p. 22):

"The southern extension of the formation has not been definitely traced, but it apparently thins out southward, appearing as an insignificant element in the series in Cecil county, Md., where Professor Uhler has described it as the bed of 'alternate sands and clays' which there rests on the Potomac and is overlain by the equivalents of the Cretaceous marl beds of New Jersey. South of this point it has not been recognized."

That Dr. Newberry found no close relations between the Amboy Clays and the Trias is also evident from the summary manner in which he dismisses this whole subject (p. 22):

"In New Jersey the Amboy Clay series is generally underlain by the Triassic red sandstones, which have been proved to be of the age of the Keuper or Upper Trias in Europe."

As to the real age of the Amboy Clays his opinions are so important that they need to be stated in full. After referring to the animal remains, in which he makes use of the same data as were employed by Professor Marsh, viz., the report of Professor R. P. Whitfield, he says (pp. 22–23):

"This evidence shows that the New Jersey clays occupy a position lower than the European chalk and higher than the upper member of the Trias. *Such other evidence as can be gained in regard to their precise geological age must be derived from their abundant plant remains*, among which are a number of species that are common to the Dakota sandstones of the interior of the continent, to the Atane and Patoot beds of Greenland —known to be Upper Cretaceous—to the Cretaceous clays of Aachen, Germany, and to the Upper Cretaceous rocks of Bohemia."

Turning then to the Older Potomac he discusses its relations to the Amboy Clays as follows (p. 23):

"The relation of the Amboy Clays to the Potomac formation of Virginia is not easily demonstrated, as the line of junction has not been fully traced, but we may say that the Potomac is the more ancient formation, and that probably *a somewhat long interval of time separated the epoch of the Potomac group from that of the Amboy Clays.* This is indicated by the *almost entire distinctness of the floras of the two formations*, which shows that *a great change took place during that interval in the character of the vegetation* which clothed the eastern shore of North America. Professor Fontaine has described, from the Potomac group of Virginia and Maryland, *365 species of plants, of which not one is certainly found in the Amboy Clays;* and the difference in the character of the vegetation is shown by the fact that in the long list furnished by Professor Fontaine *there are but 75 angiosperms* (about one-fifth of all), whereas in the New Jersey clays, throwing out fragmentary and doubtful remains, *of 156 described species all but 10 are dicotyledonous plants.*"

Having thus disposed of the possibility of the Potomac formation in Virginia being of the same age as the Amboy Clays, and having demonstrated its much greater antiquity, he sets about to discover the true geological affinities of the Amboy Clays. His conclusions may best be given in his own words (pp. 23–24):

"The relation of the Amboy Clays to the

Dakota group can be much more definitely determined, for the proportion between the angiosperms and the lower plants in the Dakota group is about the same as in theAmboy Clays, showing a similar stage of progress in the development of plant life. We have already obtained 12 species common to the two formations, a number that will undoubtedly be considerably augmented with the further exploitation of the Amboy flora. *The Dakota group is known to occupy about the middle of the Cretaceous system.* Until recently it was supposed to be the basal member of that system as developed on the North American continent, and it was believed that until about the middle of the Cretaceous period our continent had remained above the ocean level; but *it has been shown recently that considerable areas of North America are occupied by sediments deposited from the Cretaceous sea before the date of the Dakota formation*, and that on the northwestern coast, on Queen Charlotte Island, and in the Shasta group in California we have accumulations of sediment that *took place before the Dakota sandstones.* Mr. R. T. Hill and Dr. C. A. White have demonstrated that a considerable portion of the State of Texas is underlain by rocks that are the *equivalent of the Neocomian or Lower Cretaceous of the Old World.* Very recently, too, Sir William Dawson has found in the fresh-water coal-bearing deposits of western Canada fossil plants identical with some from the Kome group or Lower Cretaceous of Greenland; and a much larger collection of fossil plants obtained by the writer from the coal basin of the Falls of the Missouri in Montana, collected by Mr. R. S. Williams, contains many Kootanie or Lower Cretaceous plants, and, what is of still greater interest, a number of species that have been described by Professor Fontaine from the Potomac group of Virginia. *Thus the conclusions of Professor Fontaine as to the Wealden age of the Potomac are strikingly confirmed.* His arguments in favor of this view were that the Potomac flora was most like that of the Wealden of Europe, a few of the species being apparently identical, while it had nothing in common with any other flora known. *To this I ventured to add the suggestion that it could hardly be Jurassic*, as claimed by some writers, *since in no part of the world had angiosperm plants been found in the Jurassic, though in Europe the Jurassic rocks had yielded great numbers of plants and the flora had been carefully studied.* Now the finding of species identical with those of the Potomac in the Great Falls basin, and with them plants found in the Kootanie of Canada and the Kome deposits of Greenland, seems to place the question beyond doubt."

He was struck by the fact that several species were identical with those long ago discovered at Aachen by Dr. Debey, occurring in a formation whose geological position is known to be Upper Cretaceous, and he took the trouble to visit that locality and examine Debey's collections, a considerable number of which he purchased and brought to America. After carefully comparing these with those of the Amboy Clays, and in the light of an extensive acquaintance with other similar floras, he concludes the introductory part of his work with the following general statement (p. 33):

"The mode of accumulation of the beds at Aachen seems to have been similar to that of the Amboy Clays and the Potomac group; that is, they are local estuarine beds resting upon the Paleozoic rocks and composed of the wash of the neighboring land, in which were buried great numbers of leaves and trunks of the trees which grew upon that land. The trunks are now converted into lignite, and they are as conspicuous an element in the lithology of the group as in New Jersey. Dr. Debey supposed that his collection contained 300 to 400 species of angiosperm plants. This is perhaps an exaggeration, for he included in

his list a great many doubtful fragments; but when the floras of the Aachen beds and those of the clays of New Jersey shall be fully studied and illustrated it will undoubtedly be found that the botanical aspects are the same, and that there are perhaps as many species identical in the two formations as in those of Greenland and New Jersey. Hence, *we may fairly infer that the collections of plants from the New Jersey clays, the Dakota group, the Patoot and Atane beds of Greenland, the Aachen series of Germany, and the plant-bearing Cretaceous rocks of Bohemia fairly represent the vegetation of the world during the middle and latter portions of the Cretaceous age.*"

I do not wish to conceal the fact that Dr. Newberry's views are somewhat extreme in the direction of raising the Amboy Clays up to a level with the Dakota group of the West and the Aachen and Atane beds. My own explanation has always been that the Greenland beds are simply the northeastern extension of the Amboy Clays and Island Series, but that they may nevertheless represent a somewhat higher horizon in the same way that the Amboy Clays are higher than the Older Potomac of Maryland and Virginia, although belonging to the same general belt, either through the destruction of the lower members of the formation or because the continent at those points was out of water while the Virginia beds were in process of deposition. On this theory it would be perfectly natural that a large number of Amboy Clay species should have survived with little change into the slightly more modern period at which the Atane beds were deposited. In confirmation of this, and against the view of the great similarity between the Amboy Clay flora and that of the Dakota group, I have shown that most of the species common to the two are such as Professor Lesquereux, in studying the Dakota group, identified with Greenland forms, and I have also shown that, in a few cases at least, such identifications were not justified.* I therefore still think that the Amboy Clays, including the Island Series, are lower than Cenomanian, but any attempt to place them below the extreme summit of the Lower Cretaceous would, in the light of these facts, involve assumptions too violent to be entertained.

It certainly cannot be justly said that all this evidence, because derived from fossil plants, is without value. The floras, both of the Older and Newer Potomac, are altogether too rich and too definite to be disregarded. Taken as a whole they show as well marked differences in the character of the vegetation as could be desired. It is true that geologists and paleozoologists are generally unprepared to weigh the evidence from fossil plants, but in this case they need not know the specific nature of the plants. It is sufficient to compare the illustrations, say, of The Flora of the Amboy Clays, with those of The Potomac or Younger Mesozoic Flora.† They may be regarded simply as pictures, and it requires no practiced eye to discover that they are utterly unlike. A child would readily perceive the difference between a plate illustrating the ferns, cycads, and conifers of the Older Potomac and one illustrating the broad dicotyledonous leaves of the Amboy Clays. The contrast would be still greater if made with any of the true Jurassic floras of the world, as, for example, that of France, so profusely illustrated by the late Marquis Saporta in eight volumes containing 300 plates.‡ It therefore seems to me that the two works now before us, together with the early illustrated one of Professor Fontaine, furnish

* The Potomac Formation. 15th Ann. Rept. U. S. Geological Survey, pp. 373–374.

† Monographs of the U. S. Geological Survey, Vol. XV., plates.

‡ Paléontologie française. Végétaux. Terrain Jurassique, par le Marquis de Saporta, 4 vols. each of text and atlas, Paris, 1873–1891.

the most complete demonstration that could be made of the essential difference between the Older and the Newer Potomac, and all the proof that should be necessary to establish my fundamental thesis that, while the former must lie very near the base of the Lower Cretaceous and may even extend somewhat into the Upper Jurassic, the latter must be correlated with the extreme Upper members in the European series of Lower Cretaceous deposits.

So far as I am concerned, I have no interest whatever in the mere question of names, for example, as to whether the Wealden should be called Cretaceous or Jurassic, and I have done what I could to show that the Older Potomac was laid down under conditions very similar to those of the Wealden of England and that, in all probability, the process of deposition of portions of both at least was going on at the same time. If Professor Marsh, throughout his papers, had substituted the term Wealden for 'Jurassic' it is doubtful whether they would have given rise to any discussion, so far as the Maryland beds containing the vertebrate remains are concerned. But he has chosen to employ the term Jurassic without qualification, and there are indications that he does not mean to correlate the Potomac formation with the Wealden, but regards portions of it at least as Oolite. In his last paper* he says: "It cannot, of course, be positively asserted at present that the entire series now known as Potomac is all Jurassic, or represents the whole Jurassic. The Lias appears to be wanting, and some of the upper strata may possibly prove to belong to the Dakota." This would give the Potomac formation an enormous extension, viz., from the base of the Oolite to the Upper Cretaceous. The less than twelve hundred feet that it has been possible thus far to measure in the Potomac formation* would seem to be an exceedingly thin stratum to represent such a period, even after allowing for any amount of contemporary erosion.

Professor Marsh says that it is a reproach to science that the Jurassic has not been discovered in the eastern part of the continent. This may be true, provided it exists, but if it does not exist the finding of it would be a still greater reproach to science. His section would seem to indicate that he regards the Dakota group as forming the lowest member of the Cretaceous. This has never been maintained by any geologist. It is true that it was claimed for many years that it represented the lowest Cretaceous in America, but those who made this claim assumed the absence of the Lower Cretaceous in any part of this country. Professor Marsh's assumption, if that is what he means,† would carry with it some peculiar consequences; it would make the beds that are now known to underlie the Dakota group (the Comanche series, the Kootanie, the Shasta group, and the Queen Charlotte Island group, as well as the Potomac formation) all Jurassic. A number of these, especially those of Texas and the Pacific coast, are marine deposits and contain abundant invertebrate remains, fully establishing their Lower Cretaceous age. But

*Amer. Journ. Sci., 4th Ser., Vol. II., December, 1896, p. 436.

*15th Ann. Rept. U. S. Geol. Surv., p. 339.

†Since this was written I have had an interview with Professor Marsh and was glad to learn that he disclaims such an interpretation of his section. He maintains that the explanation on p. 144 of the 16th Annual Report United States Geological Survey was intended to prevent this impression from being gained and called my attention to the following words, and especially to those in italics: "This diagram represents the principal geological horizons *of vertebrate fossils* in North America, *as determined by the writer.*" To have justified such an interpretation his diagram should have embraced no formations from which vertebrate fossils had not been determined by him. A glance at the diagram, however, shows that there are two groups opposite which he has indicated no vertebrate remains, and one of these unfortunately is the Dakota group.

this is not all. The Shasta group, at least, is directly underlain by true Jurassic beds. It is altogether improbable that those who have established the age of these deposits from what is admitted to be the very best paleontological evidence will abandon this determination and adopt that of Professor Marsh.

When I made my slight contribution to this discussion* only Professor Marsh's two papers on the 'Geology of Block Island' had appeared, in which the evidence to establish his position was promised in the future. From the confident manner in which he spoke in those papers all expected that his next paper would contain an account of the discovery of Dinosaurs and other vertebrate remains on Block Island, Long Island, Staten Island, and Marthas Vineyard. His much fuller paper in the December number of the *American Journal of Science* is disappointing in not furnishing this evidence. Every one, I believe, would welcome any facts bearing on the subject, and all are equally interested in considering all possible data. His failure to present such evidence in this paper leads some skeptical people to suppose that it does not exist. Speaking of Gay Head, he says (p. 437): "The striking resemblance between the variegated cliffs at Gay Head, the Potomac hills in Maryland, and Como bluffs in Wyoming, will impress everyone who has seen them. That all three are of essentially the same geological age, I have good reason to believe. Two of them are certainly Jurassic, as demonstrated by typical vertebrate fossils, and *I hope soon to prove* that Gay Head, so similar in all other respects, also contains the same characteristic vertebrate fauna that marks the Jurassic,—the long missing formation on the Atlantic coast."

It would have been much better if he had actually proved this. It is always unsafe in geology to predict what we shall prove; such sweeping generalizations as Professor Marsh makes are very hazardous. To stand on Block Island and correlate its formation with that of Como bluffs in Wyoming is not the modern method of geological investigation. As he says: "The Gay Head Indians are not hostile." I did not find them so, neither did Mr. White when he made his large collection of fossil plants there. They would probably not harm a vertebrate paleontologist any more than a paleobotanist, and I submit that there is a better way of geologizing than to sit at one's 'study window' at New Haven and 'look across the Sound to Long Island.'

It is still fashionable to disparage the evidence from fossil plants, and Professor Marsh's papers would have been incomplete without the usual amount of this kind of matter. This is not the place to enter into a defense of fossil plants or to point out their value to geology. I have attempted to do this on former occasions.* I only desire here to refer to the two authors whose works I have considered as among those who do not take this view. Professor Marsh has followed most other writers in digging up the errors of the early paleobotanists while ignoring the work of the later ones, but I am surprised that he should have adopted the view which resulted from these errors, and which has long been exploded, that there is any lack of harmony between the evidence which plants afford and that of other forms of extinct life. Dr. Newberry was one of the first to correct this error and to insist that when all the evidence from plants and animals should be in there would

*Science, N. S., Vol. IV., Nov. 20, 1896, p. 757.

*Principles and Methods of Geologic Correlation by Means of Fossil Plants. American Geologist, Vol. IX., pp. 34–47; Principes et méthodes d'etude de corrélation géologique au moyen des plantes fossiles, Compte-rendu de la cinquième session du Congrès géologique international, Washington, 1891, pp. 97–109. Cf. also: Fossil Plants as an aid to Geology, by F. H. Knowlton, Journal of Geology, Vol. II., pp. 365–382.

be no lack of correspondence in their teachings. This truth is now receiving a signal confirmation by the discovery of fossil plants in marine shell-bearing deposits, especially in the Lower Cretaceous of Portugal, of Texas, and of California. Neither is the 'botanical time piece' either too slow or too fast, and the organic pendulum has always swung in perfect unison on both sides of the Atlantic. LESTER F. WARD.

WASHINGTON, D. C.

*THE AMERICAN MORPHOLOGICAL SOCIETY.**

*The Rôle of Water in Growth.* C. B. DAVENPORT.

In developing tadpoles of various amphibia the amount of water contained was determined at short intervals between the time of hatching and midsummer. These determinations showed that during the first week or two of development the amount of dry substance in the embryo remains nearly absolutely the same as it is in the just-hatched larva, where it constitutes little less than half of the whole weight. During this period the immense increment in weight which accompanies the outlining of the form of the larva and its organs is due almost solely to imbibed water. It is the specific imbibition of water then which determines the direction of differential growth in the developing tadpole. As in plants this 'grand period of growth' is followed by one of histological differentiation, during which the absolute (and relative) quantity of dry substance increases rapidly.

*The Structure and Function of the Midgut in Terrestrial Isopods.* J. P. MCMURRICH.

The general result of the study of the Isopod midgut may be summed up as follows:

1. The so-called 'midgut' of the terrestrial Isopods is of ectodermal origin and is in reality a portion of the proctodæum.

2. It is lined by an impervious layer of chitin.

3. The cells which compose it possess no definite boundaries and form an epithelial syncytium.

4. The fibrils which traverse the cells from the basement membrane to the layer of chibin are, throughout the greater part of their extent, of the same material as the basement membrane, their central ends, however, being apparently chitinous. They are not protoplasmic, as Ide has maintained.

5. The nuclei frequently show great irregularities of form; these irregularities are sometimes due to injury, but in other cases appear to be normal and to indicate a power of amœboid movement.

6. The conjugation of the nuclei, described by Ryder and Pennington, does not occur.

7. Fragmentation of the nuclei occurs as a degenerative change, but amitosis for growth or regeneration, if occuring at all, is infrequent.

8. The increase in size of the 'midgut' appears to be due not to an increase of the *number*, but to an increase of the *size*, of the cells present at the close of embryonic life.

9. Feeding experiments indicate that the midgut does not possess an absorptive function; it merely serves for the passage of undigested material to the exterior.

A paper giving in detail the evidence on which these conclusions are based is in the hands of the editor of *The Journal of Morphology*.

*The Result of the Suspension of Natural Selection as Illustrated by the Introduced English Sparrow.* H. C. BUMPUS.

Over 1,700 eggs were critically examined, and 'curves of frequency' were drawn to illustrate the differences between the European and American specimens. It was found that the American eggs presented a much greater amplitude of variation than the European, that they were smaller and that they were of a strikingly different shape.

* Concluded from page 392.